JP11-74064

[Title of the Invention] Wafer Heating Device

[Abstract]

[Problem to be Solved by the Invention]

A large-size wafer heating device is to be provided that is not damaged when rapidly heated to a high temperature of no less than 550°C and that can be repeatedly utilized with a high reliability.

[Means for Solving the Problem] When the lower surface on the side opposite to a support surface 3 for wafer W of a wafer heating device 1, wherein the upper surface of a ceramic substrate 2 in a disk form is used as the above described support surface 3 and wherein a resistance heating element 4 is buried in the substrate, is posited as a reference surface 5, the above described resistance heating element 4 is placed at a distance of 0.02 to 0.6 time of the thickness T of the above described ceramic substrate 2 away from this reference surface 5, the region P wherein this resistance heating element 4 exists is approximately circular and the most outer periphery thereof is located at a distance within 35 mm away from the side surface 6 of the above described ceramic substrate 2.

[Scope of Claim for Patent]

[Claim 1]

A wafer heating device

characterized in that the upper surface of a ceramic

substrate in a disk form is used as a support surface for a wafer and a resistance heating element is buried in the substrate;

when the lower surface on the side opposite to said support surface is posited as a reference surface, said resistance heating element is placed at a distance of 0.02 to 0.6 time of the thickness of said ceramic substrate away from the reference surface;

the region wherein this resistance heating element exists is approximately circular;

the most outer periphery thereof is within 35 mm from the side surface of said ceramic substrate.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention particularly relates to a wafer heating device used in a film formation device, such as for plasma CVD, low pressure CVD, optical CVD, PVD, or the like, and used in an etching device, such as for plasma etching, optical etching, or the like, in a manufacturing process for a semiconductor devices.

[0002]

[Prior Art]

Chlorine-based, or fluorine-based, corrosive gases have conventionally been utilized as gases for deposition,

gases for etching or gases for cleaning in film formation devices, such as for plasma CVD, low pressure CVD, optical CVD, PVD, or the like, and in etching devices, such as for plasma etching, optical etching, or the like, utilized in a manufacturing process for a semiconductor devices.

[0003]

In addition, a stainless steel heater in which a resistance heating element is incorporated has been utilized as a wafer heating device for holding a semiconductor wafer (hereinafter referred to simply as wafer) in the atmosphere of the above described gases and, at the same time, for heating the wafer to a process temperature.

[0004]

There is a problem, however, wherein the stainless steel heater becomes corroded and becomes worn down when exposed to the above described corrosive gases so that particles are generated.

[0005]

On the other hand, though a wafer heating device may be formed of graphite having a relatively excellent resistance to corrosion from corrosive gases wherein this wafer heating device is indirectly heated by means of an infrared lamp installed outside of the chamber, there is a problem wherein heat efficiency is poor in comparison with

a wafer heating device with direct heating. In addition, there is also a disadvantage wherein a film is deposited on the wall surface of the chamber of a film formation device and the occurrence of heat absorption by this film prevents the wafer heating device from being heated.

[0006]

Therefore, in order to solve such problems, a ceramic heater wherein a resistance heating element made of a high melting-point metal is buried in a dense ceramic substrate in a disk form has been proposed as a wafer heating device (see Japanese unexamined patent publication H4 (1992)-101381).

[0007]

[Problem to be Solved by the Invention]

In recent years, the outer diameter of wafers has increased, from six inches, to eight niches and to twelve inches, together with an increase in the integration of semiconductor devices and, as wafers have increased in size, large-scale wafer heating devices have become required.

[0008]

In addition, the temperature to which wafers are heated has increased year by year and the conventional temperature at which wafers are processed has increased from approximately 400°C to 550°C, and, further, to no less than 850°C, and, furthermore, a wafer heating device

allowing rapid increase in temperature in order to enhance production efficiency has become required.

[0009]

There is a problem, however, wherein thermal stress generated in a ceramic heater, of eight inches, or larger, becomes great and, thereby, the ceramic heater cracks easily at the time of increase in temperature when the ceramic heater is heated up to 550°C, or higher.

[0010]

[Purpose of the Invention]

A purpose of the present invention is to provide a large-size wafer heating device that does not crack even when rapidly heated to a high temperature of no less than 550°C and that can be repeatedly utilized with a high reliability.

[0011]

[Means for Solving the Problem]

The present inventors have conducted extensive research concerning the causes of cracking in a wafer heating device comprising a ceramic heater in which a resistance heating element is buried and have found that the region in which the resistance heating element exists inside of the ceramic substrate and the position in which the resistance heating element is buried play a role in the causes of cracking.

[0012]

That is to say, as for a wafer heating device in which the upper surface of a ceramic substrate in a disk form is used as a support surface for a wafer and a resistance heating element is buried in the substrate, the wafer heating device according to the present invention is characterized in that when the lower surface on the side opposite to said support surface is posited as a reference surface, said resistance heating element is placed at a distance of 0.02 to 0.6 time of the thickness of said ceramic substrate away from the reference surface and the region wherein this resistance heating element exists is approximately circular and the most outer periphery thereof is within 35 mm from the side surface of said ceramic substrate.

[0013]

Here, the resistance heating element of the wafer heating device according to the present invention may have any heater pattern and it is preferable for the form of the region wherein the resistance heating element exists to be an approximately circular form in order to uniformly heat a wafer of an approximately disk form. In addition, the distance between the most outer periphery of the resistance heating element and the side surface of the ceramic substrate means the distance between the most outer portion

of the resistance heating element in the heater pattern and the side surface of the ceramic substrate.

[0014]

[Embodiments of the Invention]

The embodiments of the present invention are described below.

[0015]

Fig. 1 is an oblique perspective diagram showing a wafer heating device 1 of the present invention that is referred to as a susceptor, Fig. 2 is a cross sectional view along line X-X of Fig. 1, and Fig. 3 is a pattern diagram showing the heater pattern of resistance heating element 4.

[0016]

This wafer heating device 1 comprises a dense ceramic substrate 2 in a disk form, of which the upper surface is used as a support surface 3 of a wafer W and in which a resistance heating element 4 is buried. The thickness T of ceramic substrate 2 is, in general, approximately 5 mm to 25 mm and when the lower surface on the side opposite to the above described support surface 3 is posited as a reference surface 5, the above described resistance heating element 4 is placed at a distance of 0.02 to 0.6 time the thickness T of the above described ceramic substrate 2 away from this reference surface 5.

[0017]

The heater pattern of this resistance heating element 4 is in a spiral form, as shown in Fig. 3, from the center to the outer periphery, and is formed so that the region P wherein resistance heating element 4 exists is in an approximately circular form, and so that a wafer in an approximately disk form can be uniformly heated.

[0018]

Here, one end of resistance heating element 4 positioned at the center of the heater pattern is connected to an external terminal 7 that is secured through brazing in the vicinity of the center of reference surface 5, and the other end of resistance heating element 4 located at the periphery of the heater pattern is connected to another external terminal 7 secured through brazing in the vicinity of the center of reference surface 5 via a conductor 8, provided as a layer below the above described resistance heating element 4, so that a voltage is applied between the two external terminals 7 and, thereby, resistance heating element 4 is made to emit heat so as to heat wafer W mounted on support surface 4.

[0019]

In addition, a cylindrical support for the installation of wafer heating device 1 within a chamber and for preventing the above described external terminal 7 from

being exposed to a corrosive gas within the chamber is denoted as 9.

[0020]

Here, the position in which resistance heating element 4 is buried is at a distance of 0.02 to 0.6 time the thickness T of ceramic substrate 2 away from reference surface 5 of ceramic substrate 2 because a position at a distance greater than 0.6 time the thickness T of ceramic substrate 2 away from reference surface makes resistance heating element 4 too close to support surface 3 of wafer W so that the temperature difference between the portion of support surface 3 wherein resistance heating element 4 is positioned and the portion of support surface 3 wherein resistance heating element 4 is not positioned becomes too great, and the temperature dispersion in support surface 3 exceeds ±1% so as to prevent uniform heating because of temperature dispersion due to the dispersion in the resistance of resistance heating element 4. On the contrary, the position at a distance less than 0.02 time the thickness T of ceramic substrate 2 away from the reference surface allows a great heat stress to be applied between resistance heating element 4 and support surface 3 of ceramic substrate 2 at the time of rapid temperature increase and, thereby, ceramic substrate 2 easily cracks, which cracks have a starting point in reference surface 5

as shown in Fig. 4(a).

[0021]

In addition, it is important for distance L between side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4 to be within 35 mm in order to implement a rapid temperature increase.

[0022]

This is because, a large heat stress is applied between side surface 6 of ceramic substrate 2 and resistance heating element 4 in the case that the distance L between side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4 is greater than 35 mm such that cracks occur in ceramic substrate 2, having a starting point in side surface 6 as shown in Fig. 4(b). In addition, in the case that the external diameter of ceramic substrate 2 is equal to, or slightly smaller than, wafer W, region P wherein resistance heating element 4 exists becomes too small in comparison with wafer W, so that there is a disadvantage wherein the uniformity of heating in the periphery portion of wafer W is lowered and so that chips cannot be fabricated in this periphery portion. Here, it is difficult, from the point of view of manufacture, to make distance L between side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4 less than 0.5 mm.

[0023]

Accordingly, a distance L, between the side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4, of 0.5 mm to 35 mm is desirable.

[0024]

Here, though in the present embodiment a spiral form is cited as an example of a heater pattern of resistance heating element 4, the heater pattern of the present invention is not limited to this spiral form but, rather, a variety of heater patterns, as shown in Figs. 5(a) and 5(b) for example, may be adopted as long as the form of region P wherein resistance heating element 4 exists is approximately circular.

[0025]

On the other hand, alumina, silicon nitride, sialon or aluminum nitride, which are very resistant to wear and to heat, may be used as the material for ceramic substrate 2 forming wafer heating device 1 and, in particular, aluminum nitride, from among them, having a high heat conductivity, of no less than 50 W/mk and, in some cases, of 100 W/mk, and being excellent in resistance to fluorine-based or chlorine-based corrosive gases, as well as in resistance to plasma, is suitable as the material for ceramic substrate 2.

[0026]

In addition, a material in the form of a wire or of a thin sheet film may be used for resistance heating element 4 buried in ceramic substrate 2 and the thin sheet film is more preferable than wire in the point that the time required for increasing the temperature can be shortened. Furthermore, a high melting-point metal, such as tungsten, molybdenum, rhenium or platinum, an alloy of these metals, or a carbide or a nitride of elements of groups 4a, 5a or 6a of the periodic table may be used as the material for forming resistance heating element 4, and a material which differs slightly from ceramic substrate 2 in thermal expansion may be appropriately selected and utilized.

[0027]

As for a method for manufacturing such a wafer heating device 1, in the case that resistance heating element 4 is in a thin sheet film form, first, a binder, a solvent and the like are added to a ceramic powder for forming ceramic substrate 2 so as to prepare a slip and a plurality of green sheets is formed by means of a tape formation method, such as a doctor blade method, and, after that, several green sheets are layered on each other in advance and a paste for forming resistance heating element 4 is spread thereon by means of a screen printing machine in a heater pattern having a spiral form, from the center

to the outer periphery, as shown in Fig. 3, wherein region P in which resistance heating element 4 exists is in an approximately circular form.

[0028]

Then, the remaining green sheets are layered thereon in order to manufacture a green sheet layered body and, after that, the green sheet layered body is cut into a disk form. Here, in this layering process, a design is necessary wherein the position in which resistance heating element 4 is buried is at a distance of 0.02 to 0.6 time the thickness T of ceramic substrate 2 away from reference surface 5, and wherein distance L between side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4 is no greater than 35 mm, taking the contraction of the green sheets after sintering into consideration.

[0029]

After that, the above described green sheet layered body is sintered at a temperature such that a ceramic powder may be sintered and, thereby, ceramic substrate 2, in which resistance heating element 4, in a thin sheet film form is buried, is formed and, after that, a polishing process is carried out on the upper surface of ceramic substrate 2 so as to form support surface 3 of wafer W and, at the same time, a polishing process is carried out on the

lower surface in order to form reference surface 5 and two underside recesses that reach to the above described resistance heating element 4, respectively, are provided in the vicinity of the center of this reference surface 5 and, after that, resistance heating element 4 and external terminals 7 may be electrically connected by brazing external terminals 7 through these underside recesses.

[0030]

In addition, in the case that resistance heating element 4 is a wire, first, a binder, a solvent and the like are added to a ceramic powder for forming ceramic substrate 2, and are mixed, kneaded and dried and, after that, are granulated so that granules are manufactured. These granules are filled into a metal mold of a disk form and a trench is created by means of an upper punch and, after that, the wire for forming resistance heating element 4 is installed in this trench in the heater pattern of a spiral form, from the center to the outer periphery, as shown in Fig. 3, wherein region P in which resistance heating element 4 exists is in an approximately circular form and, in addition, granules are filled in and, then, hot press formation is carried out so that ceramic substrate 2, in which resistance heating element 4 in the form of a wire is buried, is formed.

[0031]

After that, a polishing process is carried out on the upper surface of ceramic substrate 2 so as to form support surface 3 of wafer W and, at the same time, a polishing process is carried out on the lower surface in order to form reference surface 5 and two underside recesses that reach to the above described resistance heating element 4, respectively, are provided in the vicinity of the center of this reference surface 5 and, after that, resistance heating element 4 and external terminals 7 may be electrically connected by brazing external terminals 7 through these underside recesses.

[0032]

Here, though Fig. 1 shows wafer heating device 1 provided with only resistance heating element 4 inside of ceramic substrate 2, the present invention may, of course, be provided as a wafer heating device wherein an electrode 10 in a film form for electrostatic absorption or for plasma generation may be buried between support surface 3 of wafer W and resistance heating element 4, as shown in Fig. 6.

[0033]

(Example 1)

Here, wafer heating devices 1 of Fig. 1 are prepared wherein the positions in which resistance heating elements 4 are buried vary and experiments have been carried out

with respect to the temperature dispersion of support surfaces 3 and with respect to crack generation ratios of ceramic substrates 2 at the time when heat cycles were applied.

[0034]

In the present experiment, heating devices were used wherein ceramic substrates 2, in a disk form having external diameters of 300 mm and thicknesses T of 17 mm, were formed of sintered bodies of aluminum nitride having a purity of 99.9% and wherein resistance heating elements 4 made of tungsten in a sheet film form were buried in the substrate. In addition, the heater pattern of resistance heating elements 4 was in the spiral form as shown in Fig. 3 and was formed so that the regions P wherein the heating elements exist in approximately circular forms, and distance L between side surface 6 of a ceramic substrate 2 and the most outer periphery of a resistance heating element 4 was 10 mm.

[0035]

Then, a voltage was applied to wafer heating devices 1 of which the positions wherein resistance heating elements 4 are buried vary, and the heating devices emit heat so that the saturation temperature becomes 850°C and the temperature distribution on support surfaces 3 was measured by means of a Thermoviewer (brand name), and the

difference between the maximum temperature and the minimum temperature was translated into a certain per cent relative to the average temperature.

[0036]

Next, 30 wafer heating devices 1 with each of the various positions wherein resistance heating element 4 is buried were prepared and were heated to 850°C at a warm-up rate of 50°C per minute and, after that, 500 heat cycle tests wherein this saturation temperature is maintained for two hours and cooling to 150°C is subsequently carried out were performed and, after that, the crack occurrence ratios were measured.

[0037]

The results, respectively, are shown in Table 1.

[0038]

[Table 1]

No	Distance T between reference surface and resistance heating element	Temperature dispersion (%) on support surface	Crack occurrence ratio (%) of ceramic substrate
*1	0.9T	3.3	0
*2	0.8T	2.0	0
3	0.6T	1.0	0
4	0.4T	0.7	0
5	0.2T	0.6	0
6	0.1T	0.5	0
7	0.05T	0.3	0
8	0.02T	0.4	0
*9	0.015T	0.4	3.3
*10	0.010T	0.3	6.6
*11	0.005T	0.3	13.3

The * symbol indicates a result outside of the scope of the present invention.

[0039]

The results show that the temperature dispersion of support surface 3 can be restricted to 1.0 %, or less, in the case that the position wherein resistance heating element 4 is buried is at a distance less than 0.6 time of the thickness T of ceramic substrate 2 away from reference surface 5 of ceramic substrate 2.

[0040]

Here, in the case that the position wherein resistance heating element 4 is buried is at a distance less than 0.02 time of the thickness T of ceramic substrate 2 away from reference surface 5 of ceramic substrate 2, cracks in ceramic substrate occur.

[0041]

As a result of this, it is understood that the position wherein resistance heating element 4 is buried may be at a distance of 0.02 to 0.6 time of the thickness T of ceramic substrate 2 away from reference surface 5 of ceramic substrate 2.

[0042]

(Example 2)

Next, the position wherein resistance heating element

4 is buried was set at a distance of 0.1 time the thickness T of ceramic substrate 2 away from reference surface 5 of ceramic substrate 2 and 30 wafer heating devices 1 were prepared with each of various distances L between side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4 and were heated to 850°C at a rate of 50°C per minute in the same manner as in example 1 and, after that, 500 heat cycle tests wherein this saturation temperature is maintained for two hours and cooling to 150°C is subsequently carried out were performed and, after that, the crack occurrence ratios were measured.

[0043]

The results, respectively, are shown in Table 2.

[0044]

[Table 2]

No	Distance T between side surface of ceramic substrate and resistance heating element	Crack occurrence ratio of ceramic substrate (%)
1	10mm	0
2	20mm	0
3	30mm	0
4	35mm	0
*5	40mm	3.3
*6	45mm	10.0
*7	50mm	13.3

The * symbol indicates a result outside of the scope of the present invention.

[0045]

The results show that no cracks occur in ceramic substrate 2 in the case that distance L between side surface 6 of ceramic substrate 2 and the most outer periphery of resistance heating element 4 is within 35 mm.

[0046]

[Effects of the Invention]

As described above according to the present invention, as for a wafer heating device in which the upper surface of a ceramic substrate in a disk form is used as a support surface for a wafer and a resistance heating element is buried in the substrate, when the lower surface on the side opposite to said support surface is posited as a reference surface, said resistance heating element is placed at a distance of 0.02 to 0.6 time of the thickness of said ceramic substrate away from the reference surface and the region wherein this resistance heating element exists is approximately circular and the most outer periphery thereof is within 35 mm from the side surface of said ceramic substrate and, therefore, the wafer heating device is not damaged by heat stress even when rapid heating is repeated, and the uniformity of heating of the support surface of wafer W can be enhanced.

[0047]

Therefore, when wafer heating device of the present

invention is used, the film formation rate and the etching rate can be enhanced and the production efficiency of semiconductor devices can be increased and, moreover, semiconductor devices of a high quality can be constantly provided.

[Brief Description of the Drawings]

Fig. 1 is an oblique perspective view showing a wafer heating device of the present invention referred to as a susceptor;

Fig. 2 is a cross sectional view along line X-X of Fig. 1;

Fig. 3 is a pattern diagram showing a heater pattern of the resistance heating element;

Figs. 4(a) and 4(b) are pattern diagrams showing the situation of ceramic substrates wherein cracks have occurred;

Figs. 5(a) and 5(b) are pattern diagrams showing other heater patterns of the resistance heating element; and

Fig. 6 is a cross sectional view showing another wafer heating device of the present invention.

[Explanation of Symbols]

1…wafer heating device, 2…ceramic substrate, 3…support surface, 4…resistance heating element, 5…reference surface, 6…side surface, 7…external terminals, 8…conductor,

9…cylindrical support, 10…membranous electrode, W…semiconductor wafer

(2)

WAFER HEATING DEVICE

Patent Number: JP11074064
Publication date: 1999-03-16
Inventor(s): OKUDA NORIO
Applicant(s): KYOCERA CORP
Requested Patent: JP11074064
Application Number: JP19970235275 19970829
Priority Number(s):
IPC Classification: H05B3/20; H01L21/205; H01L21/3065; H01L21/68
EC Classification:
Equivalents: JP3145664B2

Abstract

PROBLEM TO BE SOLVED: To provide a large-sized wafer heating device, which is not broken even at the time of being heated rapidly up to a high temperature over 550 deg.C and can be used repeatedly and also has high reliability.
SOLUTION: In this wafer heating device, which is composed of a disc-shaped ceramic substrate 2, the upper surface of which is a retaining surface 3 of a wafer W, and a resistance exothermic body 4 buried in its inside, the resistance exothermic body 4 is arranged at the distance of 0.02-0.6 time of the thickness T of the ceramic substrate 2 from a standard face 5, which is an under surface on the opposite side of the retaining surface 3. Also, the existing area (P) of the resistance exothermic body 4 is to form a roughly round shape, and the extreme circumference thereof is located within the distance of 35 mm from the side 6 of the ceramic substrate 2.

(19)日本国特許庁（ＪＰ）　(12) 公開特許公報（Ａ）　(11)特許出願公開番号

特開平11－74064

(43)公開日　平成11年(1999)３月16日

(51)Int.Cl.⁶	識別記号	ＦＩ		
Ｈ０５Ｂ　3/20	３５６	Ｈ０５Ｂ　3/20		３５６
Ｈ０１Ｌ　21/205		Ｈ０１Ｌ　21/205		
21/3065		21/68		Ｎ
21/68		21/302		Ｂ

審査請求　未請求　請求項の数１　ＯＬ　（全　６　頁）

(21)出願番号　特願平9－235275

(22)出願日　平成９年(1997)８月29日

(71)出願人　000006633
京セラ株式会社
京都府京都市伏見区竹田鳥羽殿町６番地

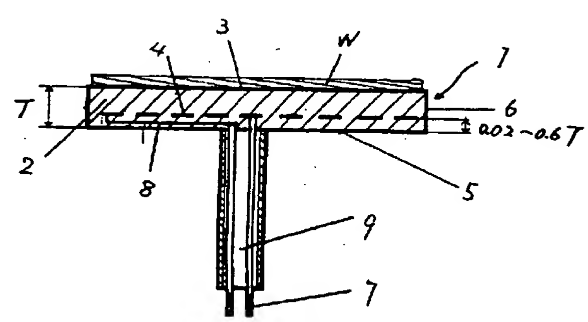
(72)発明者　奥田　憲男
鹿児島県国分市山下町１番１号　京セラ株式会社鹿児島国分工場内

(54)【発明の名称】　ウエハ加熱装置

(57)【要約】

【課題】５５０℃以上の高温に急速に昇温しても破損することがなく、繰り返し使用可能な信頼性の高い大型のウエハ加熱装置を提供することになる。

【解決手段】円盤状をしたセラミック基体２の上面をウエハＷの保持面３とし、その内部に抵抗発熱体４を埋設してなるウエハ加熱装置１の上記保持面３と反対側の下面を基準面５とし、この基準面５から上記セラミック基体２の厚みＴの０．０２～０．６倍の距離に前記抵抗発熱体４を配置するとともに、この抵抗発熱体４の存在領域Ｐが略円形であって、その最外周が上記セラミック基体２の側面６から３５ｍｍ以内の距離に位置するようにする。



【特許請求の範囲】

【請求項１】円盤状をしたセラミック基体の上面をウエハの保持面とし、その内部に抵抗発熱体を埋設してなるウエハ加熱装置において、上記保持面とは反対側の下面を基準面とし、該基準面から上記セラミック基体の厚みの０．０２～０．６倍の距離に前記抵抗発熱体を配置するとともに、この抵抗発熱体の存在領域が略円形であって、その最外周が上記セラミック基体の側面から３５ｍｍ以内にあることを特徴とするウエハ加熱装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、特に、半導体装置の製造工程におけるプラズマＣＶＤ、減圧ＣＶＤ、光ＣＶＤ、ＰＶＤなどの成膜装置や、プラズマエッチング、光エッチングなどのエッチング装置に用いられるウエハ加熱装置に関するものである。

【０００２】

【従来の技術】従来、半導体装置の製造工程で使用されるプラズマＣＶＤ、減圧ＣＶＤ、光ＣＶＤ、ＰＶＤなどの成膜装置や、プラズマエッチング、光エッチングなどのエッチング装置においては、デポジッション用ガスやエッチング用ガス、あるいはクリーニング用ガスとして塩素系やフッ素系の腐食性ガスが使用されていた。

【０００３】また、これらのガス雰囲気中で半導体ウエハ（以下、ウエハと略称する。）を保持しつつ加工温度に加熱するためのウエハ加熱装置として、抵抗発熱体を内蔵したステンレスヒーターが使用されていた。

【０００４】しかしながら、ステンレスヒーターは、上記腐食性ガスに曝されると腐食摩耗し、パーティクルが発生するといった問題点があった。

【０００５】一方、腐食性ガスに対して比較的優れた耐蝕性を有するグラファイトによりウエハ加熱装置を形成し、このウエハ加熱装置をチャンバー外に設置された赤外線ランプによって間接的に加熱することも行われているが、直接加熱のものに比べて熱効率が悪いといった問題点があった。しかも、成膜装置においては膜がチャンバーの壁面に堆積し、この膜での熱吸収が発生することから、ウエハ加熱装置を加熱できなくなるといった不都合もあった。

【０００６】そこで、このような問題点を解消するウエハ加熱装置として、円盤状をした緻密質のセラミック基体の内部に、高融点金属からなる抵抗発熱体を埋設したセラミックヒーターが提案されている（特開平４－１０１３８１号公報参照）。

【０００７】

【発明が解決しようとする課題】ところで、近年、半導体装置の集積度の向上に伴ってウエハの外径が当初６インチであったものが８インチ、１２インチと大きくなっており、ウエハの大型化に伴ってウエハ加熱装置も大型のものが要求されるようになっていた。

【０００８】また、ウエハの加熱温度も年々上昇し、従来４００℃程度であったものが、５５０℃、さらには８５０℃以上の高温で処理されるようになり、さらには生産効率を高めるために急速昇温が可能なウエハ加熱装置が求められるようになっていた。

【０００９】しかしながら、８インチ以上の大きさを有するセラミックヒーターを５５０℃以上の温度に発熱させると、昇温時にセラミックヒーター内に発生する熱応力が大きくなり、割れ易いという課題があった。

【００１０】

【発明の目的】本発明の目的は、５５０℃以上の高温に急速に昇温しても破損することがなく、繰り返し使用可能な信頼性の高い大型のウエハ加熱装置を提供することになる。

【００１１】

【課題を解決するための手段】本件発明者は、抵抗発熱体を埋設したセラミックヒーターからなるウエハ加熱装置における破損の原因について鋭意研究を重ねたところ、セラミック基体内における抵抗発熱体の存在領域と抵抗発熱体の埋設位置が関係していることを突き止めた。

【００１２】即ち、本発明は、円盤状をしたセラミック基体の上面をウエハの保持面とし、その内部に抵抗発熱体を埋設してなるウエハ加熱装置において、上記保持面とは反対側の下面を基準面とし、該基準面から上記セラミック基体の厚みの０．０２～０．６倍の距離に前記抵抗発熱体を配置するとともに、この抵抗発熱体の存在領域が略円形であって、その最外周が上記セラミック基体の側面から３５ｍｍ以内の距離に位置するようにしたことを特徴とするものである。

【００１３】なお、本発明のウエハ加熱装置は、抵抗発熱体がどのようなヒーターパターンを有するものであっても構わないが、略円盤状をしたウエハを均一に加熱するために、抵抗発熱体が存在する領域の形状を略円形とすることが望ましい。また、抵抗発熱体の最外周からセラミック基体の側面までの距離とは、ヒーターパターンのうち最も外側に位置する抵抗発熱体からセラミック基体の側面までの距離のことである。

【００１４】

【発明の実施の形態】以下、本発明の実施形態について説明する。

【００１５】図１はサセプタと呼ばれる本発明のウエハ加熱装置１を示す斜視図、図２は図１のＸ－Ｘ線断面図、図３は抵抗発熱体４のヒーターパターンを示す模式図である。

【００１６】このウエハ加熱装置１は、円盤状をした緻密質のセラミック基体２からなり、上面をウエハＷの保持面３とするとともに、その内部に抵抗発熱体４を埋設してある。セラミック基体２の厚みＴは通常５～２５ｍｍ程度で、上記保持面３と反対側の下面を基準面５と

し、この基準面５から上記セラミック基体２の厚みＴの０．０２～０．６倍の距離に前記抵抗発熱体４を配置してある。

【００１７】この抵抗発熱体４のヒーターパターンは、図３に示すように中央から外周へ向かう渦巻き状とし、抵抗発熱体４の存在領域Ｐが略円形となるように構成してあり、略円盤状をしたウエハを均一に加熱することができる。

【００１８】なお、ヒーターパターンの中央に位置する抵抗発熱体４の一方端は、基準面５の中央付近にロウ付け固定した外部端子７と接続するとともに、ヒーターパターンの周縁に位置する抵抗発熱体４の他方端は、上記抵抗発熱体４より下層に設けた導体８を介して基準面５の中央付近にロウ付け固定したもう一方の外部端子７と接続してあり、両外部端子７に電圧を印加することで抵抗発熱体４を発熱させ、保持面４に載置したウエハＷを加熱するようになっている。

【００１９】また、９はウエハ加熱装置１をチャンバー内に設置するとともに、上記外部端子７がチャンバー内の腐食性ガスに曝されるのを防ぐための円筒状支持体である。

【００２０】ところで、抵抗発熱体４の埋設位置を、セラミック基体２の基準面５からセラミック基体２の厚みＴの０．０２～０．６倍の距離とするのは、セラミック基体２の厚みＴの０．６倍より上では、抵抗発熱体４がウエハＷの保持面３に近づきすぎるため、抵抗発熱体４が位置する保持面３上と、抵抗発熱体４のない保持面３上との温度差が大きくなりすぎるとともに、抵抗発熱体４の持つ抵抗バラツキに伴う温度バラツキによって、保持面３の温度バラツキが±１％を越え、均熱化が阻害されるからであり、逆に、セラミック基体２の厚みＴの０．０２倍より下では、急速昇温時に抵抗発熱体４とセラミック基体２の保持面３との間に大きな熱応力が加わり、図４（ａ）に示すような基準面５を起点とするセラミック基体２の割れ易くなるからである。

【００２１】また、急速昇温を実現するためには、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Ｌを３５ｍｍ以内とすることが重要である。

【００２２】これは、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Ｌが３５ｍｍより大きくなると、セラミック基体２の側面６と抵抗発熱体４との間に大きな熱応力が加わり、図４（ｂ）に示すような側面６を起点とするセラミック基体２の割れが発生するからである。しかも、セラミック基体２の外径がウエハＷと同等、あるいはウエハＷより若干小さい場合、抵抗発熱体４の存在領域ＰがウエハＷより小さくなりすぎるため、ウエハＷの周縁部における均熱性が低下し、この周縁部よりチップを取り出すことができないといった不都合があるからである。ただし、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Ｌを０．５ｍｍ

より小さくすることは製造上難しい。

【００２３】従って、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Ｌは０．５～３５ｍｍとすることが良い。

【００２４】なお、本実施形態では、抵抗発熱体４のヒーターパターンとして、渦巻き状をした例を示したが、本発明のヒーターパターンはこの渦巻き状をしたものだけに限定されるものではなく、例えば、図５（ａ）（ｂ）に示すようなさまざまなヒーターパターンを採用することができ、抵抗発熱体４の存在領域Ｐの形状が略円形をしたものであれば良い。

【００２５】一方、ウエハ加熱装置１を構成するセラミック基体２の材質としては、耐摩耗性、耐熱性に優れるアルミナ、窒化珪素、サイアロン、窒化アルミニウムを用いることができ、この中でも特に窒化アルミニウムは５０Ｗ／ｍｋ以上、さらには１００Ｗ／ｍｋ以上の高い熱伝導率を有するとともに、フッ素系や塩素系等の腐食性ガスに対する耐蝕性や耐プレズマ性にも優れることから、セラミック基体２の材質として好適である。

【００２６】また、セラミック基体２に埋設する抵抗発熱体４は、線材や薄いシート膜状の形態をしたものを用いることができるが、昇温時間をより短くできる点で薄いシート膜の方が好ましい。さらに、抵抗発熱体４を構成する材質としては、タングステン、モリブデン、レニュウム、白金等の高融点金属やこれらの合金、あるいは周期律表第４ａ族、第５ａ族、第６ａ族の炭化物や窒化物を用いることができ、セラミック基体２との熱膨張差の小さいものを適宜選択して使用すれば良い。

【００２７】このようなウエハ加熱装置１を製造する方法としては、抵抗発熱体４が薄いシート膜状である時には、まず、セラミック基体２をなすセラミック粉末に、バインダーや溶媒等を加えて泥漿を作製し、ドクターブレード法などのテープ成形法により複数枚のグリーンシートを形成したあと、予め数枚のグリーンシートを積層し、その上面に抵抗発熱体４をなすペーストをスクリーン印刷機にて抵抗発熱体４の存在領域Ｐが略円形をした図３に示す中央から外周へ向かう渦巻き状のヒーターパターンに形成する。

【００２８】そして、残りのグリーンシートを積層してグリーンシート積層体を製作したあと、円盤状に切削する。なお、この積層工程において、焼成後のグリーンシートの収縮を考慮して抵抗発熱体４の埋設位置が基準面５からセラミック基体２の厚みＴの０．０２～０．６倍の距離に位置するとともに、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Ｌが３５ｍｍ以下となるように設計することが必要である。

【００２９】しかるのち、セラミック粉末を焼結させることができる温度にて上記グリーンシート積層体を焼成することにより、薄いシート膜状の抵抗発熱体４を埋設してなるセラミック基体２を形成したあと、セラミック

基体２の上面に研摩加工を施してウエハWの保持面３を形成するとともに、下面に研摩加工を施して基準面５を形成し、この基準面５の中央付近に上記抵抗発熱体４を貫通する２つの下穴をそれぞれ穿設したあと、この下穴に外部端子７をロウ付けすることにより、抵抗発熱体４と外部端子７を電気的に接続すれば良い。

【００３０】また、抵抗発熱体４が線材である時には、まず、セラミック基体２をなすセラミック粉末に、バインダーや溶媒等を加えて混練乾燥したあと造粒して顆粒を製作し、この顆粒を円盤状をした金型内に充填して、上パンチにより溝を形成したあと、この溝に抵抗発熱体４をなす線材を抵抗発熱体４の存在領域Pが略円形をした図３に示す中央から外周へ向かう渦巻き状のヒーターパターンに設置し、さらに顆粒を充填してホットプレス成形することにより、線材の抵抗発熱体４を埋設したセラミック基体２を形成する。

【００３１】しかるのち、セラミック基体２の上面に研摩加工を施してウエハWの保持面３を形成するとともに、下面に研摩加工を施して基準面５を形成し、この基準面５の中央付近に上記抵抗発熱体４を貫通する２つの下穴をそれぞれ穿設したあと、この下穴に外部端子７をロウ付けすることにより、抵抗発熱体４と外部端子７を電気的に接続すれば良い。

【００３２】なお、図１ではセラミック基体２の内部に抵抗発熱体４のみを備えたウエハ加熱装置１について示したが、本発明は、図６に示すようなウエハWの保持面３と抵抗発熱体４との間に静電吸着用やプラズマ発生用としての膜状電極１０を埋設したものであっても良いことは言うまでもない。

【００３３】（実施例１）ここで、抵抗発熱体４の埋設位置を異ならせた図１のウエハ加熱装置１を用意し、保持面３の温度バラツキと熱サイクルを加えた時のセラミック基体２の割れ発生率について実験を行った。

【００３４】本実験では、外径３００ｍｍ、厚みＴ１７ｍｍの円盤状をしたセラミック基体２を、純度９９．９％の窒化アルミニウム質焼結体により形成し、その内部にシート膜状のタングステンからなる抵抗発熱体４を埋設したものを使用した。また、抵抗発熱体４のヒーターパターンは存在領域Pが略円形をした図３に示す渦巻き状とし、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Lを１０ｍｍとした。

【００３５】そして、抵抗発熱体４の埋設位置を異ならせたウエハ加熱装置１に電圧を印加して飽和温度が８５０℃となるように発熱させ、保持面３上の温度分布を商品名：サーモビュアーで測定し、最大温度と最小温度の差が平均温度に対して何％であるかを測定した。

【００３６】次に、抵抗発熱体４の埋設位置を異ならせたウエハ加熱装置１を各３０個づつ用意し、５０℃／分の速度で８５０℃まで昇温したあと、この飽和温度で２時間保持し、そのあと１５０℃まで冷却する熱サイクル試験を５００サイクル行ったあとの割れ発生率を測定した。

【００３７】それぞれの結果は表１に示す通りである。

【００３８】

【表１】

No	基準面から抵抗発熱体までの距離T	保持面の温度バラツキ(%)	セラミック基体の割れ発生率(%)
※1	0．9T	3．3	0
※2	0．8T	2．0	0
3	0．6T	1．0	0
4	0．4T	0．7	0
5	0．2T	0．6	0
6	0．1T	0．5	0
7	0．05T	0．3	0
8	0．02T	0．4	0
※9	0．015T	0．4	3．3
※10	0．010T	0．3	6．6
※11	0．005T	0．3	13．3

※は本発明範囲外である。

【００３９】この結果、抵抗発熱体４の埋設位置がセラミック基体２の基準面５からセラミック基体２の厚みＴの０．６倍より小さい位置では、保持面３における温度バラツキを１．０％以下に抑えることができる。

【００４０】ただし、抵抗発熱体４の埋設位置がセラミック基体２の基準面５からセラミック基体２の厚みＴの０．０２倍より小さくなりすぎると、セラミック基体２の割れが発生した。

【００４１】この結果、抵抗発熱体４の埋設位置は、セラミック基体２の基準面５からセラミック基体２の厚みＴの０．０２～０．６倍の距離に配置すれば良いことが判る。

【００４２】（実施例２）次に、抵抗発熱体４の埋設位置を、セラミック基体２の基準面５からセラミック基体２の厚みＴの０．１倍の距離に設定し、セラミック基体２の側面６から抵抗発熱体４の最外周までの距離Lをそれぞれ変化させたウエハ加熱装置１を各３０個づつ用意し、実施例１と同様に５０℃／分の速度で８５０℃まで昇温したあと、この飽和温度で２時間保持し、そのあと１５０℃まで冷却する熱サイクル試験を５００サイクル行ったあとの割れ発生率を測定した。

【００４３】それぞれの結果は表２に示す通りである。

【００４４】

【表２】

No	セラミック基体の側面から抵抗発熱体までの距離T	セラミック基体の割れ発生率(%)
1	10mm	0
2	20mm	0
3	30mm	0
4	35mm	0
※5	40mm	3．3
※6	45mm	10．0
※7	50mm	13．3

※は本発明範囲外である。

【0045】この結果、セラミック基体2の側面6から抵抗発熱体4の最外周までの距離Lを35mm以内とすればセラミック基体2に割れを生じることがなかった。

【0046】

【発明の効果】以上のように、本発明によれば、円盤状をしたセラミック基体の上面をウエハの保持面とし、その内部に抵抗発熱体を埋設してなるウエハ加熱装置において、上記保持面とは反対側の下面を基準面とし、該基準面から上記セラミック基体の厚みの0．02～0．6倍の距離に前記抵抗発熱体を配置するとともに、上記抵抗発熱体の存在領域が略円形であって、その最外周が上記セラミック基体の側面から35mm以内の距離に位置＊＊するようにしたことから、急速昇温を繰り返したとしても熱応力により破損することがなく、また、ウエハWの保持面における均熱性を高めることができる。

【0047】その為、本発明のウエハ加熱装置を用いれば、成膜速度やエッチング速度を高め、半導体装置の生産効率を向上させることができるとともに、常に品質の高い半導体装置を提供することができる。

【図面の簡単な説明】

【図1】サセプタと呼ばれる本発明のウエハ加熱装置を示す斜視図である。

【図2】図1のX－X線断面図である。

【図3】抵抗発熱体のヒーターパターンを示す模式図である。

【図4】（a）（b）はセラミック基体の割れ発生状況を示す模式図である。

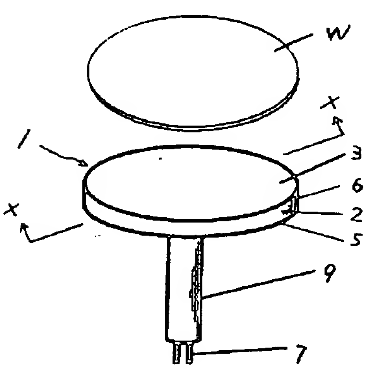
【図5】（a）（b）は抵抗発熱体の他のヒーターパターンを示す模式図である。

【図6】本発明の他のウエハ加熱装置を示す縦断面図である。

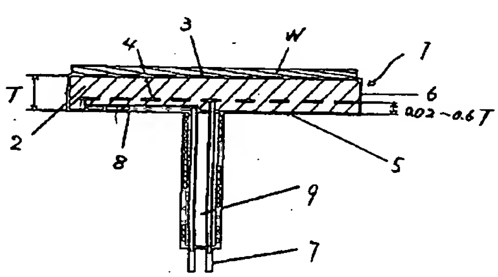
【符号の説明】

1・・・ウエハ加熱装置、　2・・・セラミック基体、　3・・・保持面、4・・・抵抗発熱体、　5・・・基準面、　6・・・側面、7・・・外部端子、8・・・導体、9・・・円筒状支持体、10・・・膜状電極、W・・・半導体ウエハ

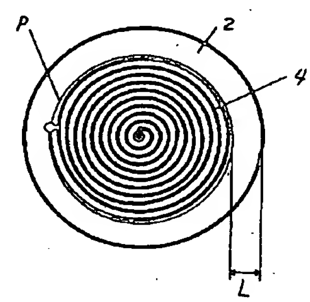
【図1】



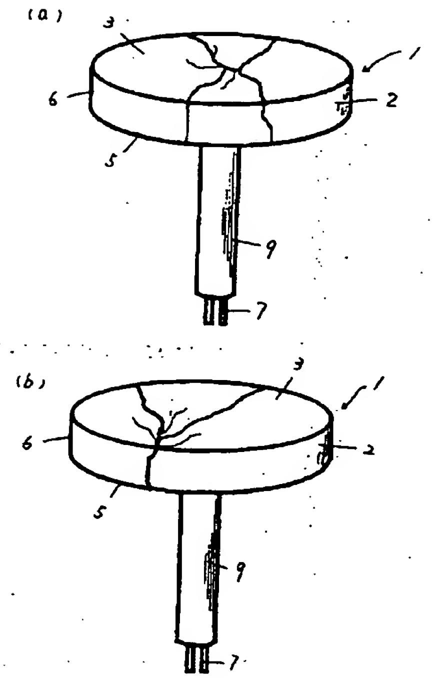
【図2】



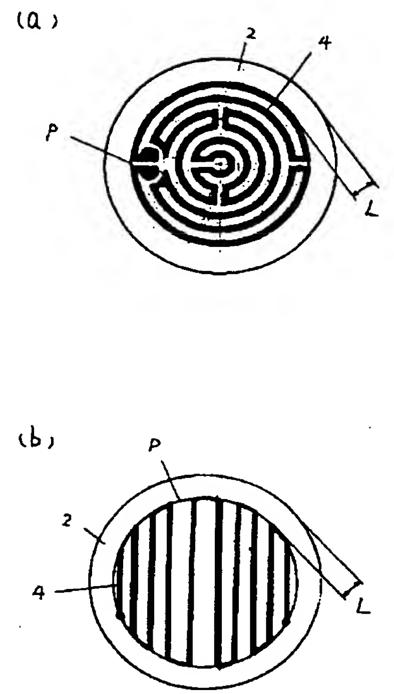
【図3】



【図4】



【図5】



【図6】